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Friend-shoring battery supply chains

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Contents

Executive summary

China's dominance over electronic vehicle battery production is a critical vulnerability in the global supply chain, in which Japan and South Korea emerge as the most compelling partners for friendshoring.

The production of electric vehicle batteries is among the greatest vulnerabilities in the global supply chain, and among the most reliant on friend-shoring away from China's industrial policies since the early 2010s, when it emerged as an industry leader internationally.

This study finds that the most likely sources for increased battery production are Japan and South Korea, as technologically savvy countries that have accomplished similar successes in moving up high-tech value chains. To adequately counter China's dominance over the sector, Tokyo and Seoul's current and prospective partners must not only support the development of these countries' battery manufacturing sectors but also apply more stringent standards for companies interested in manufacturing domestically and demonstrate greater concern for what the future of EV production means for their security.

The most likely sources for increased battery production outside of China are Japan and South Korea, as technologically savvy countries that have moved up the high-tech value chain in similar fashion.

Introduction

The American auto sector finds itself trailing behind in the domains of semiconductors and the critical minerals industry whereas China emerges as the front runner.

In the second paper of our four-paper series on friend-shoring on critical mineral supply chains, we concluded with the policy assessment that private sector participation is key to friend-shoring and that the Australian and Canadian governments and enterprises have a large role to play in the process.[1]

Since then, successive developments have advanced friend-shoring of critical mineral supply chains. In the US, for example, the Australia-United States Climate, Critical Minerals, and Clean Energy Transformation Compact, and Japan-US Critical Minerals Agreement show how the Quadrilateral Security Dialogue has expanded the supply chain security initiative to include critical minerals.[2] The Canadian government has also taken the lead, announcing ambitious plans to anchor the US-Canada partnership in critical minerals and technology, while Washington has also released new emissions standards and the Department of the Treasury outlined the parameters to make available tax credits for EV purchases. And in an interesting turn of events, American oil giant (now energy giant) Exxon Mobil announced exploration of lithium mining in Alaska.[3]

These developments reiterate the need for, and the active role played by, different governments and private entities in friend-shoring mining operations. While these are positive developments to friend-shore critical mineral supply chains, the set of challenges in the next step in the value chain of battery manufacturing is a whole different beast.

Global battery production is set to surpass one terawatt-hour (a unit of energy equal to producing 1 trillion watts for one hour) for the first time in 2023. Much of that growth is in China. Unlike in sectors such as active pharmaceutical ingredients (APIs) and pharmaceuticals, semiconductors or even critical minerals – the American auto sector has repeatedly failed (see Figure 1) to develop a viable mass market for electric vehicles (until Elon Musk's Tesla began commercial production in 2008) and, as a result, much of the value chain, including lithium-ion batteries, resides in China or other parts of East Asia. In the US, car producers focused on ever more powerful internal combustion engines and the lead-acid battery. Japan, once a leader in this sector, has seen its market share in the battery market erode over the last decade, and South Korea, while rapidly growing, cannot compete with a market as big as China's without support from an equally large market such as the United States.

The lead-acid battery was invented by French chemist Gaston Plante in 1859.[4] Interestingly, in the early years of its invention, neither the inventor nor businesses foresaw its applicability to the automobile sector. While Elihu Thomson and Edwin Houston foresaw its potential applications in lighting systems and general electrical systems, it remained a "laboratory curiosity" for decades after its invention.

Since the 1900s, American automobile manufacturers tested the EV in the American market only to face repeated failures.

The dawn of the automobile industry in the late 1800s saw the advent of the first electric cars, and by 1900 electric vehicles made up a third of total cars, giving gasoline cars a healthy competition. However, with the advent of high-speed railways and long-distance travel, by 1942 the electric car had its first death. Almost 100 years later in 1996, General Motors introduced EV1, the reimagined electric vehicle to the American automobile market. Once again, due to its limited range of 70 to 90 miles, and poor complementary public infrastructure (limited to California), demand was low, and less than 1,200 cars were manufactured.[5]

While American manufacturers and consumers were disillusioned with the promises of the EV, the demand for the vehicle picked up elsewhere. However, this took place much later – and vastly reformed.

The fatal flaw in experiments to diversify EVs away from China has been the batteries. American auto majors, for example, used lead-acid batteries to power them. These are too heavy, inefficient, and environmentally harmful to play a pivotal role in the transition to a clean energy economy.

With the nickel-hybrid batteries and later with the nickel cobalt manganese oxide batteries (NCMs), certain distance and range limitations were partly addressed. Nevertheless, American interest in EVs was limited to the West Coast of the US until the second half of 2010 because of climate-friendlier policies in some US states. Around that time, China acted swiftly and implemented targeted economic and trade policies to build out its indigenous industry. Furthermore, in the US, the debate surrounding EVs was caught in the crossfire of partisan US political bickering. As a result, despite North American scientists being at the forefront of most innovations in the battery sector, including the latest lithium iron phosphate (LFP) battery chemistry, the industry did not adequately capitalize on nor commercialize it.[6]

A decade earlier, the arguments favoring EVs were driven by climate and environmental activism. But in 2023, the bipartisan support for industrial policies for EV and aligned industries is anchored in the bipartisan consensus on the perceived “China threat”.

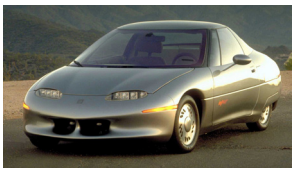
In the eastern hemisphere, the forward-looking and prudent industrial policies of the Chinese government gave Chinese industries a significant leg up. In 2011, when Bloomberg’s Betty Liu asked Elon Musk whether he foresees Chinese auto major BYD as a major competitor to Tesla, Musk laughed and replied, “Have you seen their car?”[7]

Fast-forward to 2022: BYD and Tesla are partners, and the Chinese auto giant sold 900,000 EVs in 2022, surpassing Tesla in the Chinese market.[8]

Such underestimation of competitors, combined with repeated market failures and China’s own successful industrial policy made it a major EV manufacturer and, by extension, a battery manufacturer. The Chinese government enacted policies that assisted in the complete vertical integration of the EV supply chain.[9]

Since battery manufacturing depends on the end-use sector, i.e. automobiles and energy storage systems, China rapidly monopolized the sector with little to no competition in cathode and anode manufacturing and battery production. Market dominance in the automobile end-use sector gives an economy a significant

Figure 1 – The market speaks

Year	1907 — 1942	1996 — 1999	2008 — Ongoing
Product	Detroit Electric 	EV1 	Tesla 
Result	Failure	Failure	Success

Source: Author's compilation

comparative advantage, especially if they have a large domestic market to attain economies of scale in the sectors preceding it in the value chain.

US National Security Advisor (NSA) Jake Sullivan, in his address at Brookings Institute in late April 2023, said:

> "Now, no one—certainly not me—is discounting the power of markets. But in the name of oversimplified market efficiency, entire supply chains of strategic goods—along with the industries and jobs that made them—moved overseas. And the postulate that deep trade liberalization would help America export goods, not jobs and capacity, was a promise made but not kept. … the People's Republic of China continued to subsidize at a massive scale both traditional industrial sectors, like steel, as well as key industries of the future, like clean energy, digital infrastructure, and advanced biotechnologies. America didn't just lose manufacturing—we eroded our competitiveness in critical technologies that would define the future."[10]

As Figure 1 highlights, the American market did not favor EVs. The battery sector is one where the private sector failed to match the competition with global peers. Recognizing this limitation, the Biden administration included the battery sector as one of the "national security interests" in its supply chain review and, not surprisingly, the sector is one of the largest recipients of government benefits under the Inflation Reduction Act (IRA) and Bipartisan Infrastructure Law (BIL).[11]

Charging the batteries

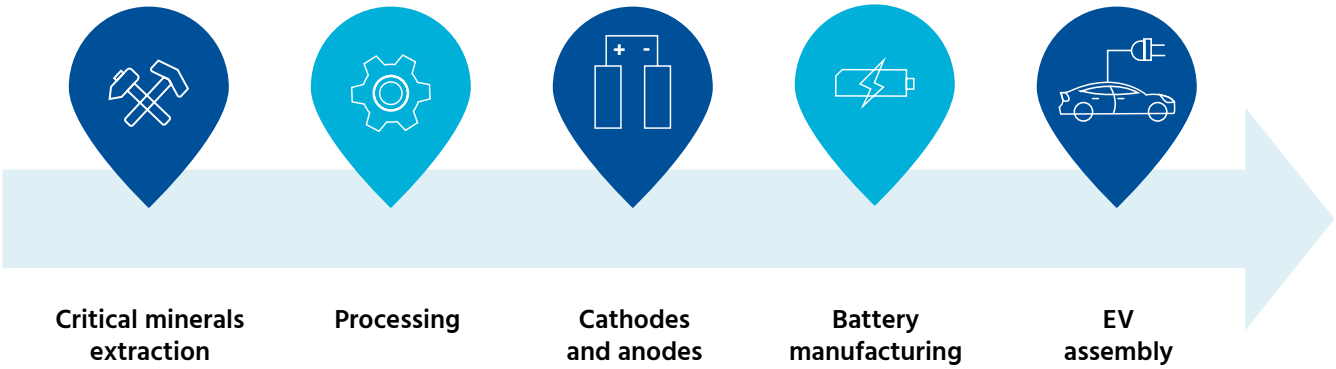
The American battery industry has not successfully capitalized on the cutting edge advancements in battery technology, which has hindered a stronger American foothold in the EV market.

The size of the US market means it will play a substantial role in diversification efforts, but a disconnect is clear: The US houses the world's largest lithium mining and processing companies, and even the largest automobile manufacturers making EVs. However, the US does not house any of the world's top 10 battery manufacturers to bridge the minerals to end-use EVs and energy storage systems (ESS).

Critical minerals are minerals that are essential to the economy and any disruption in their supply has broader national security implications. Processed critical minerals have a variety of uses from medicines to scientific research. However, over 70% of the critical minerals mined go into the manufacture of cathodes and anodes that go into batteries for mobile devices and consumer electronics and of late, a significant portion to EVs and energy storage systems (ESS). The lithium-ion battery largely in use for EVs and ESS can be developed using various chemistries such as NCM and LFP, among others.

Batteries are the highly value-added part of the value chain and moving up is a much more daunting task, particularly when there are no major American companies to take the lead. While in the case of critical mineral supply chains, large American mining corporations could partner with corporations in friendly nations to friend-shore supply chains, in the case of battery manufacturing there isn't a single American company among the top battery manufacturers of the world to ease the rapid transition to renewable energy or catch up to China's dominance in the sector.

Figure 2 – Battery supply chain



Source: US Steel Import Trends, International Trade Administration, US Department of Commerce, last accessed June 5, 2023

Cathode and anode

In simple terms, a lithium-ion battery is made up of several individual cells connected to one another. Each cell contains three main parts: a positive electrode (a cathode), a negative electrode (an anode), plus a separator. Lithium is highly reactive in its elemental form and as a result, various combinations of the metal are used in batteries. Furthermore, batteries have a separator to prevent fires. When the cathodes and anodes touch, the highly reactive nature of the element can cause a build-up of heat, eventually leading to a fire or an explosion. These make the production process a capital-intensive process, often one concentrated amongst a few large corporations. China manufactures around 70% of cathode material for NMC batteries and over 99% for the cheaper alternative LFP batteries, plus 90% of anode material and 60% of battery cells for LFP batteries.[12]

Battery anodes contain a blend of natural and synthetic graphite. Fortunately for China, it is blessed with one of the world's largest graphite reserves and is also a leading producer of the material. It mines over 65% of the graphite in the market and has a monopoly on converting it into spherical graphite. More than two-thirds of synthetic graphite produced from petroleum coke is produced in China. As a result, the global supply of naturally occurring and synthetic graphite vital for anode production is controlled by China.[13]

Unlike pharmaceuticals, critical minerals, or even semiconductors, the room for maneuvering is limited. China enjoys a near monopoly at the top of the hierarchical network of value chains in battery manufacturing. The US, on the other hand, is counting on start-ups or mid-cap companies in its reshoring and friend-shoring projects. This becomes a David vs Goliath competition without the assistance of allies and partners in East Asia.

David vs. Goliath

China's lead in battery manufacturing is new development. Targeted industrial policies jumpstarted the indigenous battery industry while replacing foreign competition.

In the battery sector, corporations with strong government support and generous subsidies have found success around the world. Of note, Chinese battery manufacturers have grown exponentially over the last decade. Amongst the top ten battery manufacturers of the world by multiple measures (including existing capacity, planned production, market share, etc.), five are Chinese conglomerates. Leading the pack is Contemporary Amperex Technology Co. Limited (CATL), followed by BYD, Gotion, and China Aviation Lithium Battery Co., Ltd (CALB).[14]

Companies such as Ganfeng Lithium are highly integrated with the entire value chain, from lithium extraction to the production of solid-state batteries (see Figure 3). CATL is a leader in the latest battery chemistry LFP and the largest producer of lithium-ion batteries with 180 GWh of production in 2022.[15]

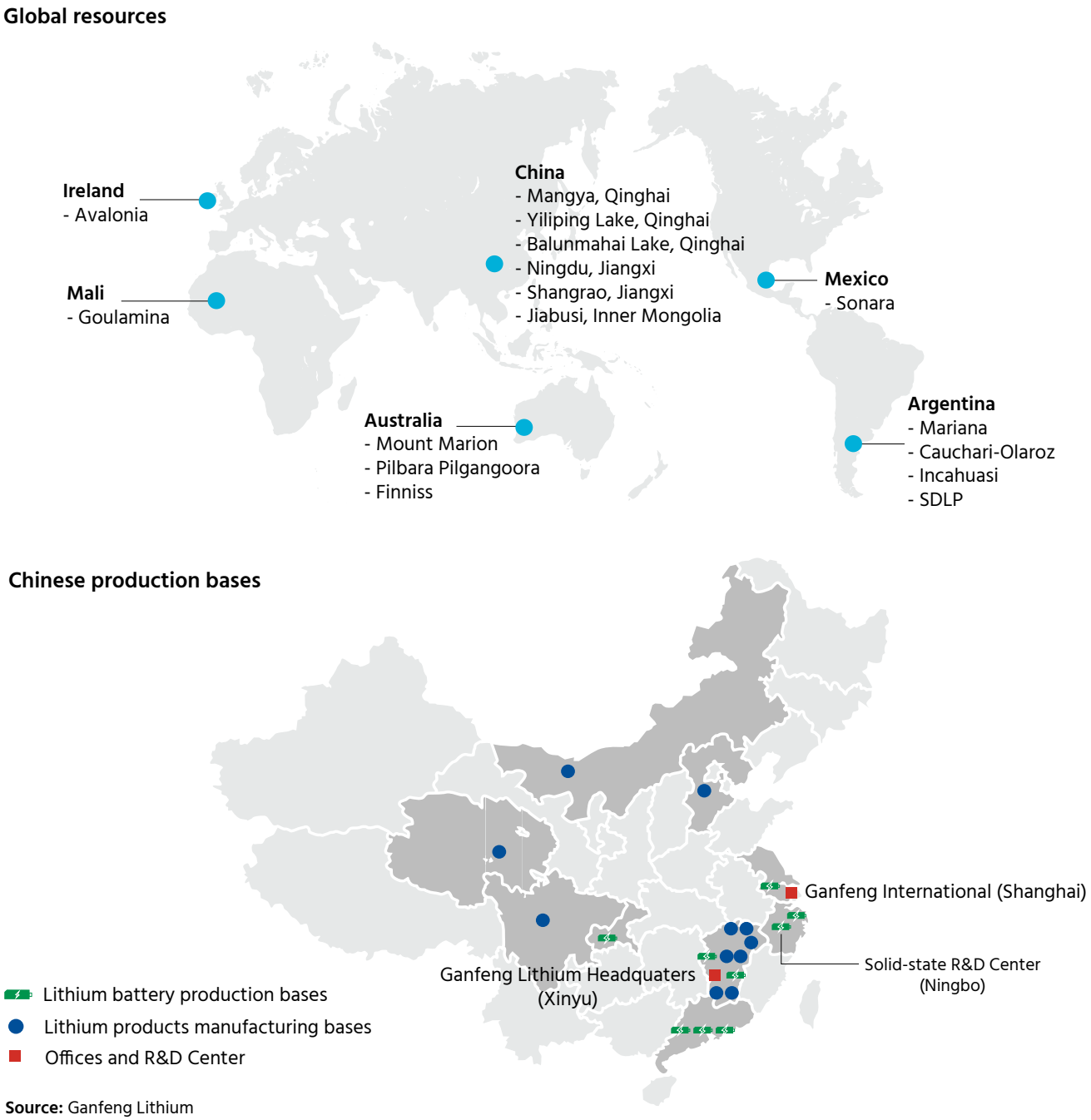
China's dominance in vertical integration across the EV value chain backed by rapid growth in the domestic EV market, and its recent technological advances increase the possibility of SVolt and Sunwoda joining the club of the world's top battery manufacturers.[16]

Interestingly, unlike its success with critical minerals, China's lead in battery manufacturing is only a recent development. A decade prior, China did not have a monopoly over the manufacturing of cathodes, anodes, or battery cells. Targeted industrial policies gave preferential treatment to domestic champions in the early 2010s that jumpstarted the indigenous industry while simultaneously replacing foreign competition. For example, until 2015, Japanese and Korean battery manufacturers were the leading suppliers of batteries in China. As a result of the

In China, targeted industrial policies gave preferential treatment to domestic champions in the early 2010s that jumpstarted the indigenous industry while simultaneously replacing foreign competition.

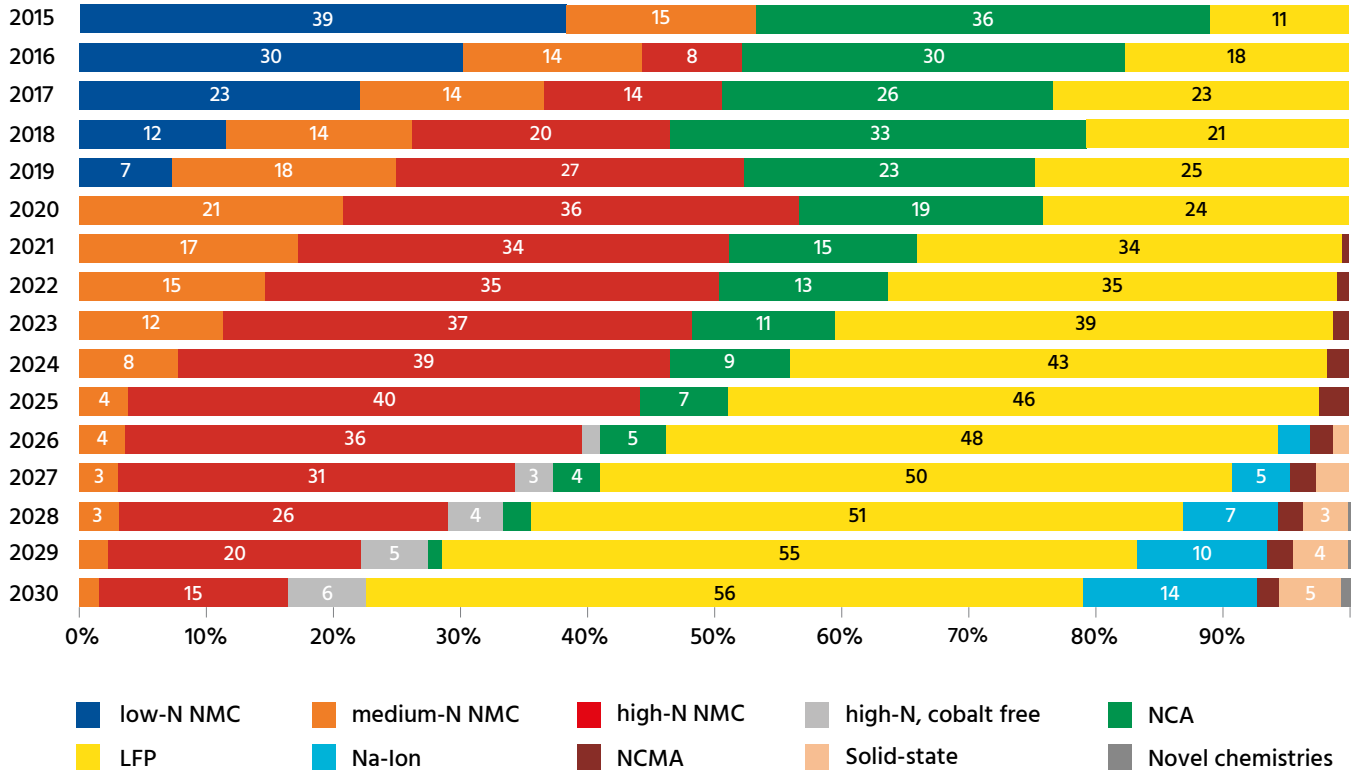
Chinese government's whitelisting of domestic companies, Korean and Japanese battery manufacturers were undercut by Chinese companies. Notably, akin to the current situation in the US, wherein it is counting on its start-ups and small-scale battery manufacturers to catch up to market leaders through the incentive-laden IRA, the Chinese state in the early 2010s generously supported what is today the behemoth CATL and BYD to take on foreign competition.[17]

Figure 3 – China's Ganfeng Lithium vertical integration across the global EV value chain



Source: Ganfeng Lithium

Figure 4 – Forecast of battery chemistry usage



Source: Rystad Energy

Nonetheless, while China made progress only in the second decade of the 21st century, the Chinese government had dedicated funds since 2001 for an indigenous battery sector under its 863 Program.[18] Strong government support assisted the battery industry in rapidly transitioning to new chemistries. For example, CATL is rapidly moving away from NCMs to LFP battery cells, and the industry is forecasted to follow suit (see Figure 3). LFP batteries are more efficient, and the minerals used in them are more easily accessible than those used in NCM batteries.

This has had consequences beyond China's domestic market. American auto majors have lost out to their Chinese peers in emerging markets such as Thailand, Vietnam, and other Southeast Asian countries.[19] Chinese auto majors have expanded auto exports to Southeast Asia and have announced the setting up of new plants in the region.

Friendly shores

The Biden administration executes friend-shoring by cooperating with Korea and Japan to increase their market share in battery manufacturing and compete more uniformly with China.

The Biden administration's industrial policy, particularly for the battery sector, while covered under the IRA, heavily relies on America's partners to execute its ambitious plans. For partners such as Korea and Japan that have lost significant market share to China's whitelisting practices on the mainland, America's IRA provides an opportunity to increase their share of manufacturing in the global market and contest a more equally poised competition with their Chinese competitors. As referenced earlier, most American companies involved in the battery material value chain are in their nascent stages and do not have the capital-raising ability to take on large corporations in a rapidly evolving and technologically changing industry. Korean companies such as LG Energy Solution (LGES), SK On, and Samsung SDI, plus Japan's Panasonic are investing in the battery sector in the North American market as a direct result of the subsidies offered under the IRA.

This, in part, is a product of the Biden administration's diplomatic offensive in getting historical rivals South Korea and Japan under one umbrella via the CHIP4 alliance and other groupings. The recent revival of Seoul-Tokyo relations bodes well for future cooperation between these parties with frequently tense relations but who both have a history of successful state-led technological innovation. Furthermore, both countries have recently shown more interest in economic security as a topic, as well as concern about China.

Japan

Until the early 2000s, Japan was the market leader in lithium-ion battery manufacturing with a 90% market share.[20] Companies such as Sony leveraged their highly automated manufacturing processes to develop automated lithium-ion manufacturing.

In the first quarter of 2023, China overtook Japan to become the world's leading exporter of automobiles, spurred by rising global demand for EVs; Japanese battery manufacturers have less than 10% of the global market share in the lithium-ion battery market and trail even their South Korean competitors, which entered the competition at a much later stage. Nonetheless, industrial policies in both Tokyo and Washington could change those figures. There are only a select few large battery makers in Japan, namely Panasonic, Mitsubishi, and Toshiba. Japanese companies such as Asahi Kasei, Toray Industries, and Sumitomo Metal Mining are market leaders in the manufacturing of separators and positive electrode materials, respectively.[21] However, without intervention in the market they could, much like their battery manufacturers, they could also begin to trail their Chinese peers.

In mid-2022, Tokyo's Economy, Trade, and Industry Ministry unveiled its industrial strategy setting a target of increasing the manufacturing capacity of Japanese manufacturers to 600 GWh (globally) by 2030, equivalent to 14.4 million units of standard EV batteries and domestic production capacity of EV and energy storage batteries at 150-gigawatt hours (GWh) by 2030.[22]

The Japanese government is targeting 20% of global market share by 2030. That target would require coordination and support from Washington, New Delhi, and Brussels. Japan had a 25% market share in 2018 which has since declined to less than 10%, with both Chinese and Korean battery makers taking big slices of the battery market pie. In the period in which Japanese battery makers lost market share, Chinese market share went from 49% to 67% and Korean battery makers went from the single digits to over 25%. Panasonic is the only Japanese company in the top 10 battery manufacturers so far in 2023.[23] To revive its dwindling share in the battery market, Japan will not only require strong domestic industrial policy, but policies limiting Chinese batteries in Japan, preferential treatment in large auto markets of the world, and strategic joint ventures that enable the other three developments. Over the last few years, Panasonic has embarked on such a strategic partnership drive through a joint venture with Toyota PPES to develop a 20 GWh capacity gigafactory.[24]

Korea

Korean battery manufacturers have a significant lead over their Japanese peers. With a third of the market with Korean companies such as LG Chemicals, SK, and Samsung, Korean battery manufacturers are strong contenders to diversify battery supply chains. Of note, while Seoul has expressed its discontent with the IRA, which it initially perceived as undercutting existing trade agreements, the existing and planned investments in the US through the generous support offered under IRA provisions give Korean companies a significant lead in the American market. Seoul was an early adopter of targeted industrial policies for the battery industry. According to the government's plan, three companies – LGES, Samsung SDI, and SK On – will be supported to manufacture next-gen batteries, as well as invest in research and development and in allied industries such as separators. In response to the US IRA, the Korean government has offered generous support to Korean businesses to capitalize on the benefits of the IRA. The Export-Import Bank

Most American companies involved in the battery material value chain are in their nascent stages and do not have the capital-raising ability to take on large corporations.

of Korea and state-owned Korea Trade Insurance are to provide around US$5.3 billion in loans to support Korean battery manufacturers in the US over five years, starting in 2023.[25]

Akin to the US approach to supporting select industries, the Korean government under Yoon has offered support to the battery industry and set an ambitious yet achievable target of 40% of the global market share by 2030.[26]

Like the US transformation of the Rust Belt into the "EV Belt," the Korean government is transforming a town known for its steel industry into its EV capital. The city of Pohang is undergoing a radical transformation with EV industries moving in. The city, known as the "miracle of Yeongil Bay" for transformational developments (including in steel[27]), is once again leading the industrial policy implementation.[28]

The Yoon government plans to expand the size and scale of investment tax credits from 8% to 15% for large companies and from 16% to 25% for small and medium-sized enterprises, and the scope of the credits to include mineral processing. These measures, scheduled to expire in 2024, have been extended until 2025.

The prospects are strong for vertical integration of the battery value chain in Korea. POSCO is actively setting up lithium processing facilities, LG Chemicals is the leading battery manufacturer in Korea (ranked 2nd worldwide), and Hyundai is a leading manufacturer of automobiles. This trio is positioned to achieve economies of scale in large markets.

An emerging trilateral

US automakers are stepping up collaboration with Japanese and Korean battery investors in North America. While China boasts cost advantages in anode materials production as a product of abundant graphite mineral resources, Japanese manufacturers are in a leading position technologically. South Korean battery maker SK On is limiting its exposure to the Chinese market by supporting an American start-up Urbix to develop anode materials in the US.[29]

The Arizona-based company, with the support of the Korean behemoth, plans to expand production in its Arizona facilities to 28,500 metric tons a year by 2025 (sufficient anode material for 300,000 to 400,000 EVs). Urbix is a small but growing American company that says its processes are environmentally friendlier than natural graphite processing undertaken in China.

To complement this process, SK has auto clients such as Ford, Hyundai, and Volkswagen. Leveraging this strong clientele, it is setting up a gigafactory in Georgia set to be operational in 2025.

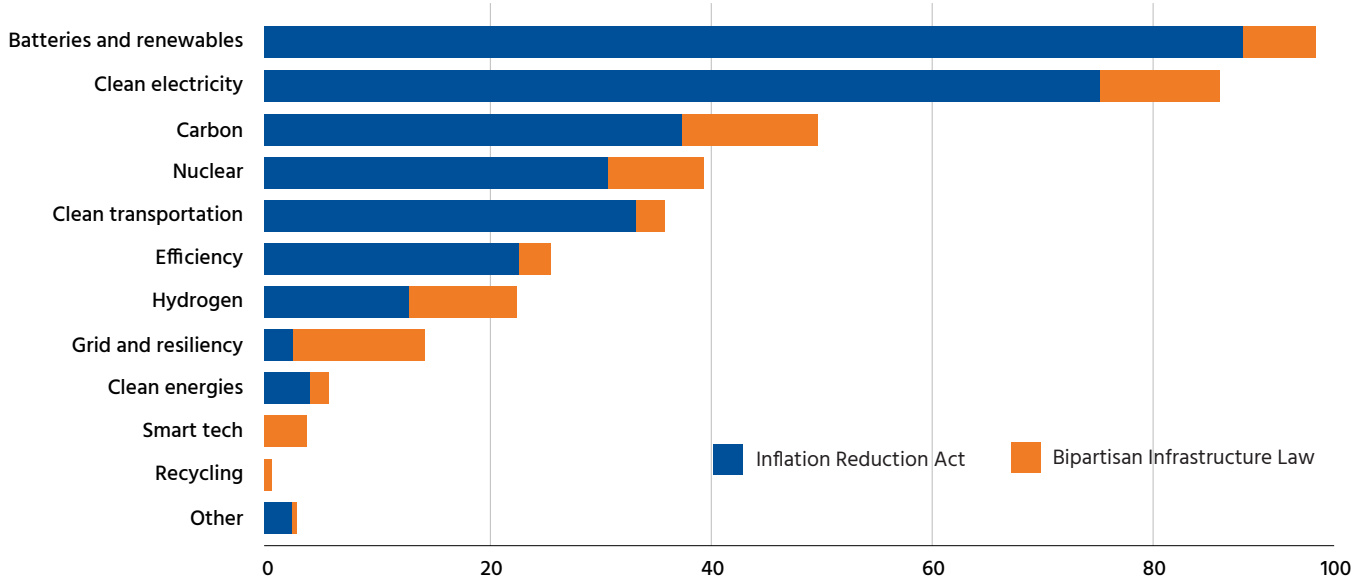
LG Energy Solution is planning on increasing its capital expenditure by 50% in 2023 from US$5 billion in 2022 as it targets an annual production capacity of 300 GWh by the end of 2023.[30]

The IRA:
An incentive-laden gauntlet

A lion's share of the IRA subsidies goes towards battery manufacturing and mineral processing facilities (see Figure 5).

In 2022, energy installations globally almost double from a year earlier to 75 GWh. China and the US both accounted for much of this increase.

Figure 5 – Funding for energy and batteries under IRA (in US$ billions)



Source: McKinsey[31]

Figure 6 – Battery manufacturing in the US

Status	Capacity
Operational	73 GWh
Partially Operational	49 GWh
Under Construction	472 GWh
Planning	305 GWh

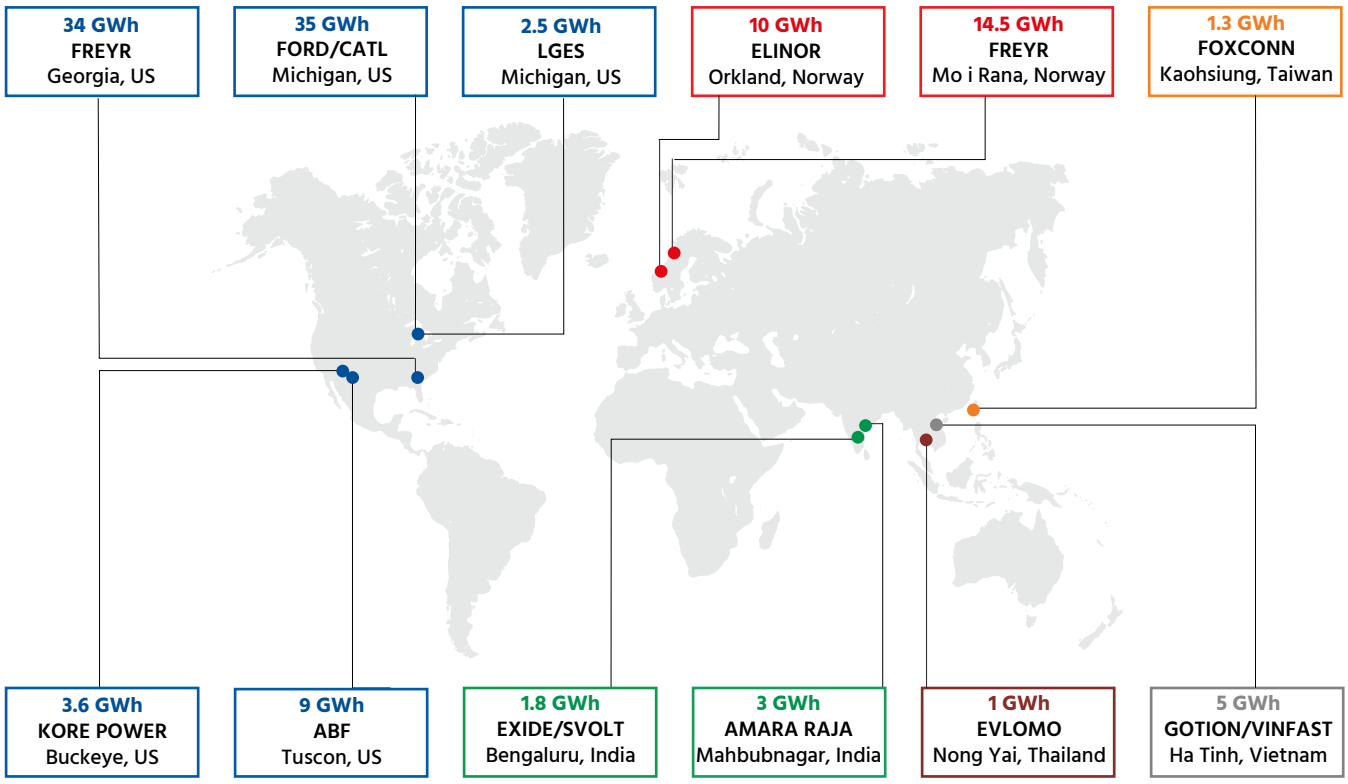
Source: Data collated by authors

Gigafactories are much easier to make operational, compared to mines. And thanks to the IRA, there is a gold rush to set up gigafactories in the US. Raising capital for gigafactories in this environment has become an easier task than raising for mining. The investment in the battery industry is about three to four times the pace of the upstream mining sector.[32] As Benjamin Moores of Benchmark Minerals put it, batteries are moving from startup to scale-up, but the mines are not being built quickly enough to fuel this growth".[33]

While the IRA's benefits provide a much-needed incentive for manufacturers, scaling at a level to compete with Chinese conglomerates is feasible only for large-scale Korean and Japanese companies. For example, while research suggests that the US capacity to produce LFP cells could increase by two-thirds by 2030, it is not reliant on American enterprise but on Korean and even Chinese Gotion's investment decisions. LG Energy Solutions has announced it will invest US$5.5 billion to build a battery plant in Arizona, including a US$2.3 billion factory producing 16 GWh of LFP batteries for energy storage systems.[34]

Nonetheless, there are a select few companies around the world that have used the benefits offered under the IRA. Pomega, a Turkish energy storage company broke ground on its first LFP plant in the US in 2023.[35] Similarly, Norwegian startup Freyr is planning on building an LFP plant in the state of Georgia with a capacity of 34 GWh at a cost of US$1.7 billion (see Figure 7).[36]

Figure 7 – Planned LFP battery production outside of China



Source: Benchmark Mineral Intelligence

Furthermore, the subsidies are not limited to battery assembly but are targeted at the more complex challenge of sourcing cathodes and anodes. As highlighted earlier, reducing overreliance on China and Chinese companies for cathode and anode production is an almost insuperable challenge as China has several comparative advantages in the production of cathodes and anodes.

The Department of Energy's Loan Program Office made the first loans to the critical minerals sector under the IRA and in July 2022, lent US$102 million to Syrah Technologies for its graphite anode production facility in Louisiana.[37] Syrah has an agreement with LGES to manufacture batteries in the US that go into batteries of American automobile companies such as Tesla and General Motors.

While the IRA's benefits provide a much-needed incentive for manufacturers, scaling at a level to compete with Chinese conglomerates is feasible only for large-scale companies.

Challenges and risk assessment

Supposedly, achieving a complete non-China supply chain for the EV industry is an unrealistic endeavor. Collaboration in some forms with Chinese entities is likely to remain crucial.

There are several challenges to friend-shoring battery supply chains. Amongst the four sectors covered under the Biden administration's supply chain review, batteries are the most challenging sector to reduce reliance on China and Chinese conglomerates.

Too many carrots and very few sticks

The United States has been particularly outspoken about the concerns associated with China's prominence in supply chains, but its initial steps in addressing this problem showed how entrenched China is in this sector Through the IRA, BIL, and other industrial policies, the Biden administration has given out incentives in the form of tax credits to a range of mineral processers and battery manufacturers. This has included incentives to Chinese companies that later ran into local opposition. A CATL project proposed in Virginia was moved to Michigan after Virginia Gov. Glenn Youngkin's vocal opposition.[38] Another backlash over the DOE's loan to Microvast, a Texas-based company with subsidiaries in China, led to the scrapping of grants to Microvast.

Nonetheless, the largest planned LFP battery facility is the Ford-CATL joint project in Michigan. Tesla uses CATL's LFP cells and Ford is partnering with both CATL in Michigan and Gotion in another undisclosed location in the US for battery production. The Michigan plant will have 35 GWh of annual capacity, enough for 400,000 vehicles a year. These partnerships are not limited to US shores. Tesla, Ford, and other American automakers are forging global partnerships with Chinese battery makers such as Gotion and CATL to secure supplies of minerals and batteries in Indonesia and other mineral-rich nations. Furthermore, America and its partners are not only playing catch up to China's dominance in the industry or supply chain but its progress in adapting the latest technology in the sector. For example, while US, Korean, and Japanese automakers were getting started on manufacturing NCM batteries, the market had moved on to LFP cells that are much cheaper and more efficient. Before US battery makers could transition, China had already gained a monopoly in LFP battery cell manufacturing. This opens the debate on allowing Chinese companies a role in the transition to renewable energy. On balance, the US government's decision on providing subsidies to Gotion or CATL will have to factor in the perceived national security risk and the risk of trailing further behind in the highly competitive global marketplace. Particularly, since the US is highly reliant on LFP cells for energy storage systems, Chinese companies could find a back door to the IRA through joint partnerships. A case in point is the announcement by Gotion on building the US' largest LFP plant in Georgia. Coinciding with the LFP production schedule, the company has also planned for a cathode processing facility in Big Rapids, Michigan to create a closed-loop supply chain, indirectly extending Chinese dominance in the sector.

If the US government does not clamp down on such deals, either on the back end or at the end-user stage of auto manufacturers, American taxpayers will be supporting the preservation and possibly the growth of Chinese battery manufacturers on US shores. In their report on US attempts at reducing reliance on China in the EV supply chain, The New York Times suggests that it is impossible to have an ex-China supply chain, quoting one expert as saying no country

can successfully manufacture electric vehicles "without having some type of cooperation with China, either directly or indirectly".[39] While it is a challenging endeavor, our analysis is not so ominous.

Betting on the wrong horse

Batteries for EVs have come a long way – from the heavy lead-acid batteries in the 1990s to the nickel-metal hydride batteries (like the ones that propel the modern Toyota Prius) to the more recent NCMs and LFPs. Lithium-ion batteries outperform nickel-cadmium batteries on every metric, The Promethean narrative focused on the next great battery breakthrough restricts the private sector from going "all in" on any particular battery chemistry and relied on a handful of battery chemistries with the right balance between reliability, performance, and economy. Moreover, over the last few years, the goalposts have been moving at regular intervals on the criteria for performance and economy. The rapid advancements in R&D in the battery sector make transitions expensive, and inefficient for smaller battery companies such as the ones in the US. The Chinese while supporting its auto industry transition to EVs using NCMs and other battery chemistries, invested in LFP, and that chemistry has now taken the battery market by storm. Similarly, over the last few years, CATL has invested in experiments with sodium-ion technology as a viable alternative to the lithium-ion batteries that dominate the EV market. While most of these inventions have occurred at a laboratory in North America, the private sector in China has been able to market-test them with increased freedom because of government support.

With sodium-ion technology and hydrogen-powered vehicles gaining market interest, without forward-looking industrial policy, US support to its indigenous and partner nation manufacturers will continue to fall short of China's advancements in the industry. CATL has already successfully tested sodium-ion technology and Chinese companies such as HiNa Battery are actively expanding production.[40] While the energy density of sodium-ion batteries is lower than lithium-ion and does not run the risk of fire, the adoption is still in its nascent stages. Nonetheless, China houses a total of 28 plants with a capacity of 3.1 GWh of sodium-ion battery capacity.[41]

Conclusion

The US government should implement industrial policies that bolster domestic battery manufacturing while also addressing the challenges faced by allied partner nations.

To address repeated market failures, the US government should not only maintain close surveillance over its industrial policies but also implement policies that address challenges in allied industries and in partner nations.

- **Bring end-use sector under the national security umbrella** – American legislators have drafted a new bill that will include the auto sector in sectors of national security concern alongside pharmaceuticals, critical minerals, batteries, and semiconductors. In early May, US Representatives Rosa DeLauro of Connecticut, Brian Fitzpatrick of Pennsylvania, and Bill Pascrell of New Jersey reintroduced the bipartisan National Critical Capabilities Defense Act, legislation that would "establish a review process over the potential offshoring of critical United States' supply chains to foreign adversaries like China and Russia".[42] Of note, the reintroduced bill included the automobile sector as a sector of national security concern. In the world's largest auto show convened in Shanghai in April 2023, global auto majors showcased their latest EVs which hold a large market share in China and even brought their boards to the auto show as a token of appreciation and commitment.[43] Given the sheer size of China's market, and its impact on batteries and mineral supply chains, it is vital for American policymakers to add the automotive sector as a sector of national security concern. Upon adding that designation, policymakers must find ways to reduce American manufacturers' reliance on China to prevent a possible weaponization of interdependence.

- **Support Korea and Japan** – As reports have highlighted, Europe's supply chain diversification or "de-risking" plans are less ambitious than Washington's

Companies such as Ford and Tesla have global partnerships with China that undercut, in an indirect way, the industrial policies of the US and multilateral initiatives.

IRA and BIL. For example, its only major battery producer, Northvolt sources its lithium from Chinese companies[44] and has not actively sought alternative shores as the US government has insisted with its partners in East Asia.[45] The US government should support South Korea and Japan in their domestic industrial policies and battery manufacturing plans not only through IRA but multilateral mechanisms such as mineral security partnerships, Quad, and other platforms. Japanese and Korean companies have been at the forefront of the battery revolution. Japanese automaker Toyota has led efforts in testing hydrogen cells for non-commercial vehicles. The Korean Ministry for Industry and Trade has allocated a significant portion of the government support towards R&D efforts. The US should capitalize on the efforts of allied nations and take note of the latest developments to address the gap with China.[46]

— **Increase R&D expenditure and incentivize diversified investments** – While the US Department of Energy has rightly prioritized the processing of minerals and battery manufacturing and recycling facilities for its loan portfolio, diversifying that portfolio to include hydrogen, green hydrogen, and new battery chemistries such as sodium-ion technology will assist the US in catching up to China's battery makers. Green hydrogen can be a viable alternative to lithium-ion batteries for vehicles that require long-distance travel or have a higher payload capacity. The private sector has initiated the adoption of green hydrogen for commercial fleets. For example, Amazon is betting on green hydrogen for its "middle mile" operations to meet the demand that lithium-ion batteries cannot fulfill. The e-commerce giant has signed a deal with Plug Power for 10,950 metric tons annually of green hydrogen to use in forklifts and heavy-duty trucks. Going forward, green hydrogen can fulfill needs where electric batteries cannot such as bus, trucks, rail and marine. It is vital for the US to increase R&D in these alternatives and increase their share in the portfolio of loans.

— **Strengthen CFIUS (sticks) and extend regulatory arm to foreign shores** – Over the last two years, the US government has placed several trade restrictions and export controls to curb the influx of Chinese goods in critical sectors, ranging from semiconductors to solar panels. Companies such as Ford and Tesla have global partnerships with Chinese battery makers and mineral processing companies in countries such as Indonesia and Australia, in an indirect way undercutting the industrial policies of the US and multilateral initiatives. Scrutinizing all global mergers and acquisitions and offtake agreements with companies of nations listed under "nations of concern" will assist in maximizing the benefits of targeted industrial policies.[47]

— **Support oil companies to strengthen critical mineral value chains** – The US government should rethink the role of oil companies in its clean energy transition. Several oil and gas companies are vying to rebrand via various battery chemistries, and hydrogen. Exxon Mobil is actively capitalizing on the momentum in the renewable energy sector. America has several such energy companies re-calibrating their operational focus to cater to the rapidly growing renewable energy sector. With generous government support through subsidies under the IRA and other legislations, in 2023, it is a gold rush to invest in sectors identified as critical to national security by the US government, particularly critical mineral processing. Downstream divisions at traditional oil companies can provide the needle coke needed for synthetic graphite and address an overreliance challenge in the vital node in the battery supply chain.

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